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ARTICLE

Integration of Cultural and Chemical Practices for Managing Texas panicum [*Urochloa texana* (Buckley) R. Webster] in South Carolina Peanut (*Arachis hypogaea* L.)

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ABSTRACT

Texas panicum has become a challenging weed in South Carolina peanut due to its season-long emergence and limited mid- to late-season herbicide options. Early residual herbicides, applied within 40 days of planting, provide insufficient control of later emerging Texas panicum. Postemergence (POST) herbicides like clethodim or imazapic are essential for the control of Texas panicum. Therefore, field studies were conducted in 2022/23 at one site and in 2023/24 at two sites to evaluate fall planted cereal rye (*Secale cereale* L.) cover crop or no cover crop followed by in-season residual (*S*-metolachlor, pyroxasulfone, acetochlor, dimethenamid-*P*) and foliar (imazapic, clethodim, paraquat, acifluorfen + bentazon) herbicides at 15, 30, 60, and 75 days after planting. Rye residue reduced Texas panicum emergence and population across environments. Among the herbicide programs, Texas panicum control ranged from 85 to 98% and population ranged from 1 to 19 plants/m^2 at 15 days after POST2 in treatments combining pyroxasulfone, dimethenamid-*P*, acetochlor or *S*-metolachlor plus imazapic. Overall, Texas panicum populations were higher in 2024 than in 2023. At 15 days after POST4, Texas panicum biomass was 0 g/m^2 in the imazapic plus residual herbicides followed by two applications of clethodim. Peanut yield ranged from 4,110 to 5,350 kg/ha across herbicide and cover crop treatments. There was no effect on peanut yield from the rye residue compared to the no-cover treatments. Although all herbicide treatments significantly improved yields compared to the untreated, a cost analysis showed that imazapic plus residual herbicides followed by two applications of clethodim provided the highest Texas panicum control (100%) at the lowest cost ($208.85/ha). In summary, these findings demonstrate that integrating cover crops and residual plus foliar herbicides enhances Texas panicum control and peanut yield.

INTRODUCTION

Weed management in peanut is challenging. Most peanut cultivars grown in the U.S. have long maturity requirements ranging from 140 to 160 days, depending on cultivar and geographical region (Henning *et al.*, 1982; Leon *et al.*, 2025). As a result, foliar and soil residual herbicides may not provide season-long weed control, which can result in mid to late-season weed flushes and other harvest problems. In addition, the peanut canopy has a prostrate growth habit and is slow to shade row middles allowing weeds an extended time to germinate and compete (Walker *et al.*, 1989; Wilcut *et al.*, 1995). Due to canopy architecture, peanut is less competitive with weeds than other crops, such as corn (*Zea mays* L.) or soybean [*Glycine max* (L.) Merr.] (Brecke and Colvin 1991; Wilcut *et al.*, 1995). The relatively poor competitive ability of peanut necessitates approaches to maintain season-long weed control to maximize yield (Jordan, 2012; Wilcut *et al.*, 1995). Finally, peanut fruit are initiated from flowers on the stems and grow via pegs into the soil surface. This prostrate growth habit is essential for pod production which limits cultivation or other tillage practices to early season (before the onset of flowering) [Brecke and Colvin, 1991; Wilcut *et al.*, 1995].

Peanut weed control typically involves the use of herbicides because alternative methods are both expensive and time-consuming (Gianessi and Reigner, 2007). Gianessi and Reigner (2007) reported that herbicides were utilized on 97% of total peanut acreage in the U.S., resulting in the prevention of 52% of yield loss. Preemergence (PRE) weed control in peanuts primarily relies on acetochlor, dimethenamid-*P*, pyroxasulfone, and *S*-metolachlor and mitosis inhibitors from the dinitroaniline family, such as pendimethalin and trifluralin (Daramola *et al.*, 2024; Leon *et al.*, 2019). The protoporphyrinogen oxidase (PPO) inhibitor flumioxazin has become an important PRE for broadleaf weed control along with acetolactate synthase (ALS) inhibitors diclosulam and imazapic for postemergence (POST) and residual grass and broadleaf weed management in peanut (Chaudhari *et al.*, 2018). Recently, the phytoene desaturase inhibitor fluridone is now registered for PRE use in peanuts (Anonymous 2023).

Texas panicum (*Panicum texanum* Buckl.) or Texas millet (*Urochloa texana* [Buckley] R. Webster) is prevalent throughout the southeastern U.S. Texas panicum is a competitive warm season annual grass that forms dense patches in fields and can grow as high as 91 cm. Texas panicum reproduces primarily by seeds which are dispersed by wind and animals (VanGessel and Johnson, 2019). Each plant has the potential to produce more than 23,000 seeds that can germinate and emerge from soil depths of 7.6 cm (Chandler and Santelmann 1969). Additionally, Egley and Chandler (1983) found that Texas panicum seed can remain viable in the soil for more than five years after burial. Moreover, Texas panicum is one of the most troublesome weed species on coarse-textured soils (Schroeder *et al.*, 1990). It will grow and produce seed under a wide range of soil moisture conditions, including drought, partially explaining Texas panicum competitiveness in crops (Schroeder *et al.*, 1990). Patterson (1990) reported that maximum Texas panicum growth occurred when the average daily temperature was 29 °C and it was hypothesized that greater weed growth would have occurred at higher temperatures. These characteristics, along with a continuous emergence pattern throughout the summer (VanGessel and Johnson, 2019), make full-season control of Texas panicum challenging in peanut (Prostko *et al.*, 2006).

Clethodim belongs to the cyclohexanedione chemical family and selectively inhibits lipid biosynthesis by blocking the enzyme acetyl-coenzyme A carboxylase (ACCase) in susceptible species (Burton *et al.*, 1987). Research has shown that properly timed clethodim POST applications effectively controlled Texas panicum (Grichar *et al.*, 1994; Johnson *et al.*, 2002; Prostko *et al.*, 2001; Wilcut *et al.*, 1990). Johnson *et al.*, (2002) showed that clethodim provided 91% Texas panicum control under moderate (>10 plants/m^2) to high (>20 plants/m^2) infestations. Prostko *et al.*, (2001) also showed that a single clethodim applications without pre-emergence herbicides provided 85% control of Texas panicum under low (3 plants/m^2) to moderate (>10 plants/m^2) weed pressure. In addition, sequential clethodim applications may be needed to control later emerging Texas panicum or escapes from heavy infestations (>20 plants/m^2) or even to increase Texas panicum control when residual herbicides are not effective (Jonhson *et al.*, 2002; Prostko *et al.*, 2001). For example, Prostko *et al.*, (2001) showed that Texas panicum control with ethalfluralin alone was less than 75%; however, clethodim applied POST following ethalfluralin improved control to 94%. However, sole reliance on clethodim POST is not advised for Texas panicum control because of lack of residual control (Johnson *et al.*, 2002). Grichar (1991) found that clethodim at 0.11 kg/ha or above provided greater than 85% control of Texas panicum when applied to grasses less than 15 cm tall. However, clethodim at 0.07 kg/ha provided erratic control especially when soil moisture was limiting and Texas panicum plants are larger than recommended resulting in less translocation and herbicidal activity in the target plants (Chernicky *et al.*, 1984; Fawcett *et al.*, 1987).

Cover crops can hinder weed seed germination and establishment. For example, cereal rye (*Secale cereale* L.) produces benzoxazinoids which contribute to weed suppression and are produced by numerous species in the Poaceae family (Barnes and Putnam, 1987; Copaja *et al.*, 2006; Kruidhof *et al.*, 2009; Putnam and Duke, 1978; Rice *et al.*, 2005). Benzoxazinoids include 2,4-dihydroxy-2H-1,4-benzoxazin-3(4H)-1 (DIBOA) which breaks down into benzoxazolin-2(3H)-1 (BOA) and 2,4-hydroxy-7-methoxy-(2H)-1,4-benzoxazin-3(4H)-1 (DIMBOA) followed by 6-methoxy-benzoxazolin-2(3H)-one (MBOA) (Copaja *et al.*, 2006; Rice *et al.*, 2005). Rye has been shown to be a promising cover crop species in suppressing weeds both physically and chemically (Silva and Bagavathiannan 2023). In one study, rye was found to be the most effective cover crop in suppressing early season broadleaf weeds across a variety of cropping systems (Nagabhushana *et al.*, 2001). Additionally, rye was found to provide significant suppression of weeds in transplanted tomato (*Solanum lycopersicum* L.) [Masiunas *et al.*, 1995]. Other studies have shown that rye and barley (*Hordeum vulgare* L.) provide significant weed-suppressive traits in no-till corn and soybean (Johnson *et al.*, 1993; Liebl *et al.*, 1992; Reddy, 2001). Large crabgrass [*Digitaria sanguinalis* (L.) Scop.] suppression in sugarbeet (*Beta vulgaris* L.) was more evident when using barley or rye compared to triticale (x *Triticosecale* Wittmack) [Dhima *et al.*, 2006].

Ryan *et al.*, (2011) demonstrated that rye can achieve an above-ground biomass of up to 8 Mg/ha. Other researchers have reported biomasses exceeding 10 Mg/ha (Poffenbarger *et al.*, 2015; Webster *et al.*, 2016). Mirsky *et al.*, (2011) observed that rye biomass increased from 4 Mg/ha in early May to 10 Mg/ha in late May. This substantial increase in biomass reduces light transmittance into the soil effectively suppressing light induced weed emergence (Teasdale and Mohler, 1993). Webster *et al.*, (2016) showed a log-logistic relationship between an increasing amount of rye residues and a reduction in germination of small-seeded weeds, such as Palmer amaranth (*Amaranthus palmeri* S. Wats.). For example, when the biomass reached 5.2 Mg/ha, light transmission to the soil decreased by almost 50% which resulted in a 50% decrease in Palmer amaranth germination (Webster *et al.*, 2016).

The challenges posed by Texas panicum in peanut cultivation underscore the dynamic nature of weed populations and the ongoing need for effective long-term weed management strategies. As weed populations evolve in response to changing agricultural practices and herbicide use patterns, a comprehensive and integrated approach is needed for managing Texas panicum. Therefore, incorporating cover crops with effective herbicide programs represents a potential solution for addressing the challenges posed by Texas panicum. Therefore, the objectives of this research project were to 1) evaluate the effect of fall planted cereal rye on the suppression of Texas panicum the following season and 2) evaluate soil residual (*S*-metolachlor, pyroxasulfone, acetochlor and dimethenamid-*P*) and foliar (paraquat, imazapic, clethodim) herbicide programs for in-season Texas panicum control.

MATERIALS AND METHODS

Field experiments were conducted at one site in 2022/23 and two sites in 2023/24 at the Clemson University Edisto Research and Education Center (EREC) located near Blackville, SC (33.36424 N, 81.33155 W; 100 m asl). Soil and other study parameters for each field site are listed in Table 1. The trial was established in fields with natural infestations of Texas panicum with supplemental overseeding in the plots. The experimental design was two (cover crop) by nine (herbicide treatment) factorial arranged in a randomized complete block design with four replications. Plot dimensions were 4 rows wide spaced 96-cm apart by 12-m long. Cereal rye var. 'Wrens Abruzzi 'was planted at 56 kg ha^{-1} in the fall of 2022 and 2023, then terminated the following spring using glyphosate (Roundup PowerMAX 3, Bayer CropScience, St. Louis, MO) at 1.12 kg/ha three to four weeks before peanut seeding, leaving the residue standing. Study sites were fertilized with potassium (90 kg/ha) based on the soil test recommendations provided by the Soil Testing Laboratory at Clemson University one month before trial initiation. Cover crop biomass samples were taken using a 1-m^2 quadrat in mid-May of every year and were dried in the oven at 41 ºC and weighed. Plots were strip tilled (Unverferth Manufacturing, Kalida, OH) one day before peanut planting. Peanut cultivars Sullivan (Isleib *et al.*, 2015) and Georgia 16HO (Branch 2017) were planted in 2023 and 2024, respectively, at a depth of 5 cm using a four-row John Deere 1700 planter (Deere and Co., Moline, IL, USA) at a rate of 20 seed per meter of row (Table 1). Disease and insect management were carried out according to the guidelines published in the South Carolina Peanut Production Guide (Anco *et al.*, 2023). At the end of the season, the middle two rows of each plot were inverted and then harvested with a plot combine. Peanut plot yield was converted from kg/plot to kg/ha.

Table 1. Experimental field study parameters for the peanut and cover crop trials conducted at Edisto Research and Education Center in 2022/23 and 2023/24.

Environment	Rye planting date	Rye termination date	Variety	Planting date	Soil parameters			Inversion date	Harvest date
					Series[a]	Organic matter	pH		
						%			
2023-1	11-22-22	5-5-23	Sullivan	6-5-23	Varina loamy sand	1.4	5.8	10-17-23	10-24-23
2024-2	11-14-23	4-23-24	Georgia 16HO	5-7-24	Varina loamy sand	1.2	5.9	10-7-24	10-22-24
2024-3	11-14-23	4-23-24	Georgia 16HO	5-7-24	Fuquay sand	0.7	5.6	10-7-24	10-24-24

[a]Soil series at the study locations were Fuquay sand (loamy, siliceous, thermic Arenic Plinthic Paleudults); Varina loamy sand (clayey, kaolinitic, thermic Plinthic Paleudults).

After planting, flumioxazin was applied at 0.11 kg/ha across all plots including the untreated for management of broadleaf weeds. Residual herbicide treatments included acetochlor (Warrant, Bayer CropScience, St. Louis, MO) at 1.6 kg/ha, dimethenamid-*P* (Outlook, BASF, Research Triangle Park, NC) at 0.6 kg/ha, pyroxasulfone (Zidua, BASF) at 0.15 kg/ha, and *S*-metolachlor (Dual Magnum, Syngenta, Greensboro, NC) at 1.1 kg/ha. Foliar herbicide treatments included acifluorfen + bentazon (Storm, UPL, Research Triangle Park, NC) at 0.28 + 0.6 kg/ha, clethodim (Cleanse 2EC, Winfield Solutions, LLC., St. Paul, MN) at 0.13 kg/ha, imazapic (Cadre, BASF) at 0.07 kg/ha, and paraquat (Gramoxone 3S, Syngenta) at 0.2 kg/ha. Herbicide treatments were applied to the middle two rows leaving the outside rows as running checks using a four-nozzle boom equipped with TeeJet 8002 VS nozzles (Spraying Systems Co., Springfield, IL) 15 days after planting (DAP) [POST1], 30 DAP (POST2), 60 DAP (POST3), and 75 DAP (POST4) days after planting in water using a backpack sprayer calibrated to deliver 140 L/ha at 207 kPa.

The effectiveness of each herbicide treatment was determined visually by rating the presence of Texas panicum relative to its density in the non-treated control of each replication on a percentage scale of 0 to 100 where 0 = no control and 100 = complete control or plant death. Texas panicum population density was estimated by counting the number of plants that fell within two 0.25-m^2 quadrats randomly placed into the two center rows of each plot. Percent visual Texas panicum control ratings and population counts were collected at 15 days after POST2 (DAP2) and 15 days after POST4 (DAP4). In addition, Texas panicum was clipped at the soil surface at 15 DAP4, dried in the oven at 41 °C, and weighed. At maturity, the middle two rows of each plot were inverted and then harvested using a plot combine (Table 1).

Data were subjected to a three-way ANOVA model using the PROC MIXED procedure in SAS 9.4 software considering the factorial treatment arrangement to assess the differences between cover crops and herbicides treatments across different locations and years (environments). Fixed factors were environment, cover crops and herbicide application. Random factors were replication nested inside of environments. Normality and homogeneity of variances were evaluated for each model by the Shapiro-Wilk and Anderson-Darling goodness of fit tests and by visual assessment of the residual plots. The data fit the assumptions of normality of residuals and homogeneity of variances. A global F-test was used to evaluate significance and treatment means were separated using Fisher's protected LSD with an alpha value of 0.05.

RESULTS AND DISCUSSION

Environmental conditions in 2024 were more favorable for Texas panicum growth and establishment than in 2023. In 2024, there was less rainfall (22 mm less from May to October than in 2023) and higher temperatures (average of 1.4°C increase May to October) than in 2023 (Table 2). These environmental factors may have increased Texas panicum germination and emergence resulting in the higher observed Texas panicum populations. Texas panicum can thrive under a wide range of soil moisture conditions, including drought, but the optimum growth rates were higher because of elevated temperatures (29°C average) in 2024 (Patterson, 1990; Schroeder *et al.*, 1990). Weed growth is often enhanced at these elevated temperatures (Patterson, 1990).

Table 2. Accumulated monthly precipitation and average temperature at Edisto Research and Education Center in 2023 and 2024.

Month	2023		2024	
	Rainfall	Temperature	Rainfall	Temperature
	mm	C	mm	C
April	122.9	17.6	60.1	18.2
May	105.1	20.3	76.9	23.7
June	169.9	24.7	83.1	28.4
July	155.5	27.6	115.3	29.5
August	208.5	28.3	223.9	26.5
September	81.9	23.5	183.5	24.1
October	64.9	18.6	16.2	18.9

Cereal Rye Biomass

The biomass produced by rye varied significantly across environments ($P < 0.0001$). The highest biomass levels were observed in the 2023-1 and 2024-2 environments with 4,080 and 3,720 kg/ha, respectively, followed by the 2024-3 environment at 2,630 kg/ha. In comparison, Price *et al.*, (2007) reported rye biomass on a fine sandy loam ranged from 2,840 to 5,130 kg/ha in Alabama. Similarly, Yenish *et al.*, (1996) observed rye biomass between 4,540 and 5,140 kg/ha in sandy loam soils in North Carolina, while Bauer and Reeves (1999) recorded an average biomass of 5,300 kg/ha in loamy sand soils in South Carolina. Ashford and Reeves (2003) also observed in Alabama a two-year average rye biomass of 10,100 kg/ha highlighting the variation in biomass production under different soil and environmental conditions. Previous research stated that the most productive cover crops tend to be the most weed-suppressive (McKenzie-Gopsill *et al.*, 2022). The rye biomass produced in the two years of this study reduced Texas panicum emergence and establishment the following growing season compared to the no cover treatments.

This highlights the importance of selecting a cover crop that can suppress weeds through a variety of mechanisms (MacLaren *et al.*, 2019; Smith *et al.* 2015; Smith *et al.* 2020). Plant-plant interactions and resource capture mechanisms, such as allelopathy effects, relative growth rate, canopy light interception, and chemical biomass composition can be equally as important (Christina *et al.*, 2021; Kruidhof *et al.*, 2008; Lawley *et al.*, 2012). For instance, previous research found that oats may decompose faster than other small grains, such as rye, limiting the length of weed control (Malpassi *et al.*, 2000). In addition, VanGessel and Johnson (2019) also reported that a thick layer of cover crop residue plays a crucial role in reducing seedling density and inhibiting seedling growth. Therefore, a cover crop species with tissue resistant to decay, such as rye, would be the most beneficial. In addition, rye has rapid growth and canopy development which can suppress weed germination and establishment (Baraibar *et al.*, 2018).

Texas panicum Control 15 DAP2

There was no three-way interaction among environment, cover crop, and herbicide treatment for Texas panicum control at 15 DAP2 (P = 0.5261), but the environment interaction with herbicide (P = 0.0423) and cover crop (P < 0.0001) was significant. Therefore, Texas panicum control 15 DAP2 were separated by environment, cover crop, and herbicide treatment.

Across herbicide treatments, Texas panicum control at 15 DAP2 was higher where rye was used as a cover crop (90% vs 83%) in the 2023-1 environment. However, no differences were observed between rye and no cover in the 2024-2 and 2024-3 environments at 15 DAP2 (data not shown).

Table 3. Texas panicum percent control and population as affected by fall cover crops and in-season herbicide treatments 15 days after POST2 at the Edisto Research and Education Center in 2022/23 and 2023/24[a].

Treatment[bc]		Control[d]						Population[d]					
POST1[e]	POST2[f]	2023-1		2024-2		2024-3		2023-1		2024-2		2024-3	
		---------------%--------------						----------plants/m²------------					
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + *S*-metolachlor + bentazon + acifluorfen	79	d	77	cde	82	cd	15	ab	35	ab	20	b
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + pyroxasulfone + bentazon + acifluorfen	89	ab	81	bc	88	bc	9	bc	28	b	11	c
paraquat + *S*-metolachlor + bentazon + acifluorfen	*S*-metolachlor + imazapic	89	ab	85	ab	94	ab	10	bc	19	c	4	d
paraquat + *S*-metolachlor + bentazon + acifluorfen	pyroxasulfone + imazapic	91	a	89	a	98	a	8	c	13	c	1	d
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + acetochlor + bentazon + aciflurofen	78	d	75	e	77	e	18	a	36	a	20	b
paraquat + *S*-metolachlor + bentazon + acifluorfen	acetochlor + imazapic	89	ab	87	a	97	a	10	bc	18	c	2	d
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + dimethenamid-P + bentazon + aciflurofen	85	bc	77	de	81	de	13	abc	39	a	24	b
paraquat + *S*-metolachlor + bentazon + acifluorfen	dimethenamid-P + imazapic	93	a	88	a	97	a	7	c	17	c	2	d
untreated								18	a	38	a	36	a
		P < 0.0001						P < 0.0001					

[a] Means within columns followed by the same letter are not significantly different according to Fisher's Protected LSD Test at P ≤ 0.05.
[b] Herbicide use rates: acetochlor, 1.6 kg/ha; acifluorfen + bentazon, 0.28 + 0.6 kg/ha; dimethenamid-P, 0.6 kg/ha; imazapic, 0.07 kg/ha; paraquat, 0.2 kg/ha; pyroxasulfone, 0.15 kg/ha; *S*-metolachlor, 1.1 kg/ha.
[c] Non-Ionic Surfactant at 0.25%v/v included with all imazapic treatments.
[d] Averaged over cover crop (P = 0.9176).
[e] POST1, herbicide treatments applied 15 days after planting.
[f] POST2, herbicide treatments applied 30 days after planting.

Among all the herbicide programs, the imazapic based treatments provided 89% or better Texas panicum control followed by paraquat + pyroxasulfone + bentazon + acifluorfen at 86% across the three environments (Table 3). In the 2024-2 environment, Texas panicum control was 85% or higher in imazapic plus residual treatments. However, in the 2024-3 environment, paraquat + pyroxasulfone + bentazon + acifluorfen and imazapic based treatments provided 88% or better Texas panicum control (Table 3). However, reduced Texas panicum control was observed with paraquat + acetochlor + acifluorfen + bentazon, paraquat + *S*-metolachlor + bentazon + acifluorfen, and paraquat + dimethenamid-*P* + bentazon + acifluorfen treatments. Texas panicum control ranged from 75 to 85% in the paraquat based treatments across the three environments (Table 3). In contrast, previous studies have shown that Texas panicum control was 95% with paraquat tank mixed with bentazon and *S*-metolachlor (Weirich, 2007). However, when acifluorfen was added to the mixture, Texas panicum control was 66%. In addition, Texas panicum control varied from 82% to 95% 4 weeks after an early POST of acetochlor plus paraquat plus bentazon (Kharel *et al.*, 2022). Grichar *et al.*, (2015) reported that *S*-metolachlor and acetochlor provided 67% to 92% Texas panicum control. Janak and Grichar (2016) also reported that *S*-metolachlor alone provided 75 to 78% Texas panicum control compared to 75 to 99% control with pyroxasulfone. Other studies have shown reduced Texas panicum control with *S*-metolachlor (Grichar *et al.*, 1994; Steele *et al.*, 2005). Steele *et al.*, (2005) observed Texas panicum control with pyroxasulfone ranged from 84 to 96% compared to 75 to 85% with *S*-metolachlor. Enhanced Texas panicum control was attributed to the longer residual activity of pyroxasulfone.

Texas panicum Population 15DAP2

There was no significant interaction among environment, cover crop, and herbicide treatment (P = 0.9176); however, the interactions between environment and herbicide treatments (P < 0.0001) and cover crop and herbicide treatments (P = 0.0050) was significant; therefore, data were separated by cover crop and environment.

Across environments, Texas panicum populations ranged from 4 to 23 plants/m^2 and 9 to 36 plants/m^2 in the rye and no cover, respectively (data not shown). The populations in the imazapic based treatments and paraquat + pyroxasulfone + bentazon + acifluorfen were lower compared to the untreated in the rye cover crop. Overall, populations were higher in the no cover treatments; however, all herbicide treatments across cover crop treatments reduced Texas panicum compared to the untreated (data not shown)

Texas panicum populations 15 DAP2 showed a similar trend to the control results. Populations were less than 10 plants/m^2 in the rye cover crop in imazapic based treatments at 15 DAP2 (Table 3). Similarly, Texas panicum populations in the no cover were 15 plants/m^2 or less in paraquat plus bentazon + acifluorfen and imazapic based treatments (Table 3). Across the cover crop treatments, Texas panicum populations ranged from 1 to 39 plants/m^2 across the three environments. In the 2023-1 and 2024-2 environments, Texas panicum populations were 19 plants/m^2 or lower in the bentazon + acifluorfen and imazapic based treatments. Texas panicum populations were 11 plants/m^2 or less in paraquat plus bentazon + acifluorfen and imazapic based treatments in the 2024-3 environment (Table 3).

Overall, the rye cover crop plots had lower Texas panicum populations compared to the no cover plots across the different herbicide programs, marking a general trend of suppression in both years of the study. In a three-year Alabama study, Price *et al.* (2007) found that treatments including rye cover provided enhanced weed control over fallow treatments in conservation-tilled peanuts, with an average increase of 10 to 37%. Under low-input herbicide treatments, weed control in rye plots ranged from 78% to 93% compared to 60% to 88% in fallow treatments. High-input herbicide systems achieved 81% to 94% weed control when combined with a rye cover, versus 61% to 91% in non-cover plots. Similarly, Yenish et al. (1996) observed short-term weed suppression with non-rolled rye cover in no-till corn. In a no-till soybean, Reddy (2003) reported that rye cover reduced total weed density by 27% six weeks after planting.

Texas panicum Biomass 15DAP4

There was no significant interaction among environment, cover crop, and herbicide treatment (P = 1.0000); however, interactions between environment and herbicide treatments (P = 0.0266) and cover crop and herbicide treatments (P < 0.0001) were significant. Therefore, data were presented separately by herbicide treatment and cover crop.

No differences were observed in Texas panicum biomass 15 DAP4 among the herbicide treatments. There was no Texas panicum biomass observed in *S*-metolachlor + imazapic, pyroxasulfone + imazapic, and acetochlor + imazapic, and dimethenamid-*P* + imazapic treatments across the two cover crop regimes (Table 4). In the untreated, Texas panicum biomass was 388 and 253 g/m^2 in the no cover and rye treatments, respectively. In the paraquat + acetochlor + bentazon + acifluorfen treatment, Texas panicum biomass was 11 and 21 g/m^2 in the rye and no cover, respectively (Table 4). Texas panicum biomass in the paraquat + *S*-metolachlor + bentazon + acifluorfen treatment was 4 and 11 g/m^2 in the rye and no cover, respectively, and 5 and 4 g/m^2 in the paraquat plus bentazon + acifluorfen treatments in the rye and no cover, respectively (Table 4). Similarly, Texas panicum biomass was 6 and 9 g/m^2 in paraquat + dimethenamid-*P* + bentazon + acifluorfen treatment for rye and no cover, respectively (Table 4).

Peanut Yield

There was no significant interaction among environment, cover crop, and herbicide treatment (P=0.4670), herbicide treatment and environment (P=0.1292), and cover crop and herbicide treatment (P = 0.1714); therefore, the data was combined across cover crop and environment and presented by herbicide treatment (P < 0.0001).

Peanut yield ranged from 4,110 to 5,350 kg/ha in this study. No differences in peanut yield were observed across the herbicide treatments; however, there was a significant difference between the non-treated and the herbicide treatments (Table 5). In the no cover crop (no herbicide) treatment, elevated Texas panicum population density (36 plants/m^2) reduced peanut yield. This highlights the competitive nature of Texas panicum in peanut which not only reduces yield but also impedes harvest efficiency because pods can become embedded in the extensive root system and stripped from the peg during inversion process (Buchanan *et al.*, 1982). Although no differences were observed in yield between no cover and rye, Price *et al.*, (2007) found that under low to high input systems following a fall rye cover crop, peanut yields were higher than in systems where there was no winter crop cover crop.

Table 4. Texas panicum biomass as affected by fall cover crops and in-season herbicide treatments 15 days after POST4 at the Edisto Research and Education Center in 2022/23 and 2023/24 [a].

Treatment[bc]				Biomass[d]			
POST1[e]	POST2[f]	POST3[g]	POST4[h]	Rye		No cover	
				-------- g/m^2-------			
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + *S*-metolachlor + bentazon + acifluorfen	clethodim	clethodim	4	b	11	b
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + pyroxasulfone + bentazon + acifluorfen	clethodim	clethodim	5	b	4	b
paraquat + *S*-metolachlor + bentazon + acifluorfen	*S*-metolachlor + imazapic	clethodim	clethodim	0	b	0	b
paraquat + *S*-metolachlor + bentazon + acifluorfen	pyroxasulfone + imazapic	clethodim	clethodim	0	b	0	b
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + acetochlor + bentazon + aciflurofen	clethodim	clethodim	11	b	21	b
paraquat + *S*-metolachlor + bentazon + acifluorfen	acetochlor + imazapic	clethodim	clethodim	0	b	0	b
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + dimethenamid-P + bentazon + aciflurofen	clethodim	clethodim	6	b	9	b
paraquat + *S*-metolachlor + bentazon + acifluorfen	dimethenamid-P + imazapic	clethodim	clethodim	0	b	0	b
untreated	--	--	--	253	a	388	a
				$P < 0.0001$			

[a] Means within columns followed by the same letter are not significantly different according to Fisher's Protected LSD Test at $P \leq 0.05$.

[b] Herbicide use rates: acetochlor, 1.6 kg/ha; acifluorfen + bentazon, 0.28 + 0.6 kg/ha; clethodim, 0.13 kg/ha; dimethenamid-P, 0.6 kg/ha; imazapic, 0.07 kg/ha; paraquat, 0.2 kg/ha; pyroxasulfone, 0.15 kg/ha; *S*-metolachlor, 1.1 kg/ha.

[c] Non-Ionic Surfactant at 0.25%v/v included with all imazapic treatments and Crop Oil Concentrate at 1% v/v included with all clethodim treatments.

[d] Averaged over environment ($P = 0.8423$).

[e] POST1, herbicide treatments applied 15 days after planting.

[f] POST2, herbicide treatments applied 30 days after planting.

[g] POST3 = 60 days after planting.

[h] POST4 = 75 days after planting.

Herbicide Cost

The herbicide treatment costs in this study ranged from $200.20 to $246.15. In this study, the imazapic containing herbicide treatments provided the highest Texas panicum control and the lowest cost per hectare (average cost of $208.85/ha), regardless of cover crop regime (Table 5). The cost of herbicides and adjuvants was based on price averages compiled from the South Carolina Agronomic Crop Production Budgets – Clemson University Cooperative Extension and Department of Agriculture and Applied Economics – University of Georgia Cooperative Extension. The cost of the application was not included in the calculations.

Table 5. Peanut yield and herbicide program cost as affected by fall cover crops and in-season herbicide treatments at Edisto Research and Education Center in 2022/23 and 2023/24[a].

Treatment[bc]						
POST1[f]	POST2[g]	POST3[h]	POST4[i]	Peanut yield[d]		Cost[e]
				kg/ha		$/ha
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + *S*-metolachlor + bentazon + acifluorfen	clethodim	clethodim	5150	a	227.74
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + pyroxasulfone + bentazon + acifluorfen	clethodim	clethodim	5060	a	237.11
paraquat + *S*-metolachlor + bentazon + acifluorfen	*S*-metolachlor + imazapic	clethodim	clethodim	5220	a	209.94
paraquat + *S*-metolachlor + bentazon + acifluorfen	pyroxasulfone + imazapic	clethodim	clethodim	5350	a	206.64
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + acetochlor + bentazon + aciflurofen	clethodim	clethodim	5040	a	240.48
paraquat + *S*-metolachlor + bentazon + acifluorfen	acetochlor + imazapic	clethodim	clethodim	5200	a	200.20
paraquat + *S*-metolachlor + bentazon + acifluorfen	paraquat + dimethenamid-P + bentazon + aciflurofen	clethodim	clethodim	5260	a	246.15
paraquat + *S*-metolachlor + bentazon + acifluorfen	dimethenamid-P + imazapic	clethodim	clethodim	5000	a	218.61
untreated				4110	b	---
				$P < 0.0001$		---

[a] Means within columns followed by the same letter are not significantly different according to Fisher's Protected LSD Test at $P \leq 0.05$.

[b] Herbicide use rates: acetochlor, 1.6 kg/ha; acifluorfen + bentazon, 0.28 + 0.6 kg/ha; clethodim, 0.13 kg/ha; dimethenamid-P, 0.6 kg/ha; imazapic, 0.07 kg/ha; paraquat, 0.2 kg/ha; pyroxasulfone, 0.15 kg/ha; *S*-metolachlor, 1.1 kg/ha.

[c] Non-Ionic Surfactant at 0.25%v/v included with all imazapic treatments and Crop Oil Concentrate at 1% v/v included with all clethodim treatments.

[d] Averaged over environment (P=0.1292) and cover crop (P = 0.1714)

[e] Based on price averages compiled from the South Carolina Agronomic Crop Production Budgets – Cooperative Extension Service Clemson University and Department of Agriculture and Applied Economics – University of Georgia.

[f] POST1, herbicide treatments applied 15 days after planting.

[g] POST2, herbicide treatments applied 30 days after planting.

[h] POST3, herbicide treatments applied 60 days after planting.

[i] POST4, herbicide treatments applied 75 days after planting

SUMMARY AND CONCLUSIONS

This study demonstrated the complex dynamics of Texas panicum management in peanut. The warmer and drier season of 2024 led to increased Texas panicum populations compared to 2023, demonstrating the adaptability of Texas panicum to challenging conditions and underscoring the difficulty of effective control under such stresses. Despite this variability, fall-planted rye cover crop consistently reduced Texas panicum emergence and establishment confirming the weed suppression ability of rye without any impact on peanut yield.

Foliar in combination with residual herbicides after crop emergence reduced Texas panicum emergence and in-season populations before clethodim was applied. However, paraquat in combination with *S*-metolachlor, acetochlor, or dimethenamid-*P* were generally less effective in controlling Texas panicum. Imazapic plus with pyroxasulfone, dimethenamid-*P*, acetochlor, or *S*-metolachlor provided better overall Texas panicum control indicating that imazapic had both residual and foliar activity on Texas panicum. These results in the study agree with previous research indicating that combining residual herbicides, such as pyroxasulfone, with POST herbicides improves residual control of grass weeds (Baughman *et al.*, 2018; Edenfield *et al.*, 1999; Grichar *et al.*, 2012; King *et al.*, 2007; King and Garcia, 2008). Scott *et al.* (1995, Scott *et al.*, 1998) also stated that tank mixtures of dimethenamid-*P* applied with foliar herbicides have shown synergistic control of grass weeds which was attributed to enhanced absorption. Prostko *et al.*, (2011) observed that over-lapping residual herbicides could be an effective means for controlling weeds with season-long emergence patterns including Benghal dayflower (*Commelina benghalensis* L.), ALS-resistant Palmer amaranth, and Texas panicum. However, it is worth noting that even with a comprehensive approach, control of Texas panicum is limited and full–season control will require clethodim POST in peanuts (Grichar *et al.*, 2021).

Economic considerations are important. The most effective treatments in this study had the lowest cost which provided a cost-effective solution for Texas panicum infested fields. Furthermore, the addition of cover crops and conservation tillage provided another management option in peanut fields in the southeastern US. Besides weed suppression, cover crops can provide several benefits including conserving soil moisture after termination, increasing soil organic matter, and reducing soil erosion (Clark, 2007; Dabney *et al.*, 2001; Kaspar and Singer, 2011; Lu *et al.*, 2000). However, previous studies have reported that cover crop biomass only provides early-season weed suppression and additional weed management strategies are needed for long-term weed control and prevention of yield losses (Masiunas *et al.*, 1995; Teasdale, 1996; Teasdale and Abdul-Baki, 1998).

Combining fall-planted rye, effective foliar and residual herbicides, and strategic application timings enhanced Texas panicum control even under challenging environmental conditions. However, the season long germination of Texas panicum emphasizes the need for clethodim in peanut for effective, season-long control. This integrated study confirms previous findings that cover crops can suppress early-season weed emergence; however, full-season management of Texas panicum requires a comprehensive management plan incorporating cover crops, conservation practices, and effective herbicides. The results from this study provide a valuable foundation for enhancing Texas panicum management in peanut production systems in the Southeastern U.S.

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